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A simplified frequency equation and its approximate solution of a beam with an incipient crack from a wave perspective

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ABSTRACT

This paper presents a simplified frequency equation and its approximate solution to predict the modal frequencies of a beam with an incipient crack. The physical implication of the simplified frequency equation is fully described from a wave perspective for the cracked beam with arbitrary support conditions. The approximate solution of the proposed frequency equation is derived from a wave perspective as well. The asymptotic equivalence is demonstrated between the approximate solution and that obtained by the first order perturbation method as the mode number increases. The validity of the proposed approach is demonstrated through comparison to both numerical results from finite element analysis and experimental data.

Keywords

beam; incipient crack; frequency equation; modal frequency; wave perspective; structural health monitoring

1. Introduction

The effects of an incipient crack on the dynamic behavior of a beam has been of a great concern for structural health monitoring applications [1,2]. Among them, it is well-known that the modal frequencies of a cracked beam decrease compared to those of an intact one because the crack reduces the stiffness of a beam. The previous studies have reported that the changes of the lower-mode frequencies are very small due to an incipient crack because the lower frequency global modes of a beam with long characteristic wavelengths tend to be insensitive to local damage [3,4]. Since the size